MEMORANDUM

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TO: Steven Parkin (UDAQ) STI Ref. No. 900031

FROM: Dana Coe

SUBJECT: Recommended revisions to the ammonia inventory

I have completed a review of the draft ammonia emission inventory, and I would like to make a few suggestions for revisions and further research, which I have described in this memorandum. My suggestions pertain to the following source categories: soils, poultry, residential/commercial fuel combustion, off-road mobile sources, wetlands, miscellaneous domestic sources, wastewater treatment plants, and point sources. I am continuing to do some research of my own regarding emissions from soils, wastewater treatment plants, and wetlands, as explained in the body of this memorandum. Please let me know if I can be of any further assistance.

NATURAL EMISSIONS FROM SOILS

For the desert scrub areas in the lowland valleys of the domain, I recommend using an emission factor of 0.4 kg/km^2-day (rather than 1.0 kg/km^2-day). For the ungrazed grasslands, I recommend using an emission factor of 1.5 kg/km^2-day (rather than 5.8 kg/km^2-day). These alternative emission factors that I am recommending are mid-range values from a 1991 article by Schlesinger and Hartley.

U.S. Geological Survey (USGS) digital land use/land cover (LULC) maps can be used to estimate land areas and spatially allocate emissions. The USGS maps include the LULC categories listed in **Table 1**. Table 1 also tabulates my preliminary recommendations for emission factors. I am currently gathering some additional information regarding ammonia emissions from grasslands and deserts, and I may revise these recommendations in the next two weeks.

Table 1. USGS LULC categories and preliminary recommended emission factors.

Land Use/ Land Cover Category	Subcategory	Recommended Emission Factor (kg NH_3/km^2-day)
Urban or Built-up Land		1.0 × unpaved fraction
Agricultural Land	Cropland and Pasture*	3.65 and 2.0, respectively
	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas	3.65
	Confined Feeding Operations*	2.0
	Other Agricultural Land	3.65
Rangeland	Herbaceous Rangeland*	1.5
	Shrub and Brush Rangeland*	0.4
	Mixed Rangeland*	1.0
Forest Land		1.0
Water	Streams and Canals	0
	Lakes	0
	Reservoirs	0
	Bays and Estuaries	STI to calculate
Wetland	Forested Wetland	1.0
	Nonforested Wetland	STI to calculate
	Barren Land	0.4
	Perennial Snow or Ice	0

* In addition to emissions from natural soils, emissions from cattle livestock can be assigned to these land use categories.

POULTRY

I recommend using the county-by-county Agricultural Census data for poultry populations rather than a disaggregation technique. Also, the Agricultural Census inventory of poultry may need to be adjusted for the average lifespans of the birds. I suggest that the local poultry producers' association should be contacted to ask if this is the case. The poultry producers' association for California told us that the average lifespan of a chicken in California was around 50 days, which meant that the annualized average poultry population was around one-seventh of the Agricultural Census poultry inventory.

MISSING AREA SOURCES

A few sources have not yet been included in the ammonia inventory. Ammonia emissions from on-road mobile sources should be scaled and spatially distributed according to the NO_x emissions for the on-road mobile inventory (when the on-road mobile inventory becomes available). Emissions for

residential/commercial combustion sources and off-road mobile sources should be calculated according to estimated fuel usage (see **Table 2**). In other ammonia inventories, emissions from ammonia refrigeration have been estimated roughly (412 lb NH_3 per employee) and spatially distributed with employment in the food and kindred products sector (SIC code 20XX). Residential emissions can be spatially distributed according to housing units (Census Bureau data), and commercial emissions can be spatially distributed to commercial zones. Off-road mobile sources can be distributed according to land use categories that are consistent with the specific emissions category (e.g., airport equipment assigned to airport locations, recreational vehicles assigned to parks and ski areas, etc.).

Table 2. Source categories and preliminary recommended emission factors for missing area sources (Gharib and Cass, 1984).

Source Category	Subcategory	Emission Factor (lb NH_3 per unit of fuel consumed)	Fuel Consumption Units
Jet aircraft		0.31	billion Btu
Gasoline airplanes		1.9	
Diesel train engines		0.31	
Diesel ships		0.31	
Residential/ Commercial Fuel Use	Natural Gas	0.52	million cubic feet
	Liquified Petroleum Gas (LPG)	0.05	thousand gallons
	Residual Oil	0.92	thousand gallons
	Distillate Oil	1.0	thousand gallons
	Coal	2.2	ton

Also, it should be noted in the documentation for the inventory that fertilizer use, which does not occur in the wintertime, has been omitted from this wintertime inventory. If this inventory is to be used for springtime, fall, or summer modeling applications, then ammonia emissions from fertilizer use should be estimated and included.

NATURAL EMISSIONS FROM THE WETLANDS SURROUNDING THE GREAT SALT LAKE

STI will estimate annual and seasonal emission rates for this source category, and will provide the gridded spatial surrogate field. The preliminary wintertime emission factor for this category is 3.6 kg/km^2-day.

MISCELLANEOUS DOMESTIC SOURCES

Sutton et al. (2000) provided a recent distillation of current research, citing the emission factors listed in **Table 3**. These emission factors are recommended for use in the Salt Lake City regional inventory.

Table 3. Recommended emission factors for miscellaneous domestic sources.

Source Category	Emission Factor
Cigarette smoking	4.1 mg NH_3 per cigarette
Respiration	3.6 g NH_3 per person-year
Perspiration	17 g NH_3 per person-year
Infants <1 yr	14.2 g NH_3 per child-year
Infants ***1-3 yr***	***17.7 g NH_3 per child-year***
Cats	***134 g NH_3 per cat-year***
Dogs	***741 g NH_3 per dog-year***
Untreated Human Wastes*	***60 g NH_3 per person-year × Untreated Fraction***

* This emission factor was estimated based on the ratio between adults' and infants' daily protein consumptions (54 g/day : 16 g/day × ***17.7 g/person-yr***).

Note that according to the Centers for Disease Control, the prevalence of smoking among adults in Utah was 14.2 percent in 1998, and the U.S. average cigarette consumption rate was 18.6 cigarettes per smoker per day.

WASTEWATER TREATMENT PLANTS

The emission factor that was used for wastewater treatment plants (0.118 lb/million gallons) applies to the water treatment processes and does not include emissions from sludge processing. On the basis of the measurements that STI conducted at the Visalia, California municipal wastewater plant, the emissions from sludge handling are probably 2-3 orders of magnitude larger than emissions from water treatment. I recommend contacting the largest wastewater plants in the region to gather information about the sludge production and handling processes, such as quantities produced, sludge processes conducted (e.g., digestion, drying, etc.), and nitrogen contents of sludges at various stages of handling.

I am currently working on alternative methods to calculate ammonia losses from sewage sludge. We can generate rough estimates by assuming that 15-25 percent of the total nitrogen content of sludge is lost as ammonia (Click and Reed, 1975; Sutton et al., 1995; and Sutton et al., 2000). Or, we can apply an emission factor of 3-7 lb NH_3 per ton of sludge processed (Adams, 1995).

POINT SOURCES

I recommend that Radian be requested to include point sources of ammonia in their review and analysis of the point source inventory. Their review and analysis should focus on the following issues.

- Determine whether any electric power plants in the area inject ammonia into their flue gases in order to control NO_x emissions. If so, gather data from these sources (flue gas NH_3 concentration and flow rate) in order to estimate emissions.
- Determine whether any of the waste management districts/companies operate composting operations in the region. If so, apply recent research results gathered for composting facilities in California's South Coast Air Quality Management District in order to estimate emissions.
- Review the existing point sources inventory for ammonia for completeness and reasonableness. The existing inventory includes emissions due to fuel combustion at electric utility plants, refineries, and other industrial point sources.
- Identify the following types of facilities/source types in the region and estimate their ammonia emissions: manufacturing plants for ammonia, nitrate fertilizer, urea, ammonium nitrate, and ammonium phosphate; coke manufacturing; and catalytic cracking at refineries.

REFERENCES

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